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ABSTRACT

In this study, hypermedia technology was used to support prospective elementary teachers in publicly articulating their personal pedagogical theories, revisiting and revising them over time in light of new experiences and learning within the context of an innovative teacher preparation program. Given the need to incorporate opportunities for engaging prospective teachers in reflection and making their personal theorizing explicit and the potential of hypermedia authoring to support this kind of reflection and make thinking visible, this study aimed to answer the question: What are the prospective elementary teachers' views of teaching and learning science as they became transparent through their Web-based philosophies? Specifically, the questions that guided this research are: (1) What is the nature of prospective elementary teachers' philosophies about science teaching and learning? (2) In what ways does the Web-based portfolio task support thoughtful reflection associated with learning to teach science? and (3) In what ways does the technology contribute to the portfolio task? The study finds that the Web-based philosophy task was conducive to making prospective elementary teachers' implicitly held personal pedagogical theories explicit and promoting their revision in light of new experiences and learning. (Contains 25 references.) (MVL)

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USING A WEB-BASED TASK TO MAKE PROSPECTIVE ELEMENTARY TEACHERS' PERSONAL THEORIZING ABOUT SCIENCE TEACHING EXPLICIT

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Many researchers have argued that by the time prospective teachers get to college they hold well-established beliefs and practices related to being a teacher (Pajares, 1992). These beliefs include ideas about what it takes to be an effective teacher and how students ought to behave, and, though usually unarticulated and simplified, they are brought into teacher preparation programs (Clark, 1988 and Nespor, 1987, as cited in Pajares, 1992). Not surprisingly, these views of teaching and learning have been shown to influence classroom teaching practice (Pajares, 1992).

Prospective teachers' theories and beliefs about teaching and learning have been defined by the literature as '*personal theorizing*' (Barone, 1988; Ross, 1992; Schubert, 1992). Teacher theorizing includes the development of their own pedagogical and moral platforms, which, together with more concrete subject matter and social interaction preferences, can result in their own curricular materials and activities (Barone, 1988). As Schubert (1992) argued, teacher educators need to respect the integrity and the sophistication of personal theorizing by prospective teachers as a valuable and necessary form of research and teacher education. Therefore, targeting prospective teachers' personal theorizing is essential to supporting their learning to teach.

The question becomes, "How can teacher educators get an insight into prospective teachers' personal theorizing? One approach to making prospective teachers' personal theorizing transparent is the use of networked technologies that help to make thinking

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visible (Bransford, Brown, & Cocking, 2000; Collins, 1990). The purpose of this qualitative case study was to examine prospective elementary teachers' personal theories about science teaching and learning and how they changed over time as they engaged in an integrative, web-based task. A secondary purpose of the study was to investigate the role of technology in making prospective teachers' personal theorizing explicit.

Theoretical Underpinnings

This study draws upon two bodies of literature: teaching as community property which pursues the scholarship of teaching (Shulman, 1998) and making thinking visible through networked technologies as a core feature of the cognitive apprenticeship model of instruction (Collins, 1990). It is important to make prospective teachers' views on learning and teaching explicit, to discuss and analyze these views critically, and to encourage prospective teachers to reflect on these views and their implications for science instruction (Aguirre & Haggerty, 1995). As Prawat (1992) argued, "the investigation of teachers' beliefs is a necessary and valuable avenue of educational inquiry" (p. 326).

Making work transparent implies the possibility of peer review, overcoming isolation and improvement of the quality of teaching. Shulman (2000) noted that, "By engaging in purposive reflection, documentation, assessment and analysis of teaching and learning, and doing so in a more public and accessible manner, we not only support the improvement of our own teaching but our colleagues as well" (p. 50). In pursuing the scholarship of teaching, teachers endeavor to make their work and ideas public, to subject them to critical examination, and to exchange them so that others can build upon them (Shulman, 1998). An emerging characteristic of a teacher as a professional is this ability

to articulate, evaluate, engage in, and respond to criticism about teaching, their own practice and student learning (Lyons, 1998). Similarly, Shulman (1998) illuminated the importance of communicating ideas:

> Having to take our teaching from the private to the public sphere, having to think about how we are going to engage in it, but also how we will come to understand what we are doing as teachers in ways that will permit us to organize what we do, display and communicate and converse about it to our own community, will have an improvement effect on teaching. (p. 12)

Taking private beliefs, theories and practices from the private to the public sphere has an effect on not only prospective teachers' personal theorizing but on their peers' theorizing as well. But how can we move from the private to the public sphere? Networked technologies have the potential to do that by making thinking visible.

Collins (1990) discussed how networked technologies make the invisible visible and the tacit knowledge explicit. Specifically, he stated that the benefits of technology include making visible the parts of a process that are not normally seen. By revealing these processes in detail, learners will have the chance to figure out how processes unfold. In the case of teacher education, by making their thinking visible, prospective teachers engage in reflective and metacognitive activities about their own learning but also they get a better understanding about their peers' thinking about teaching.

In this study, hypermedia technology was used to support prospective elementary teachers in publicly articulating their personal pedagogical theories, revisiting and revising them over time in light of new experiences and learning within the context of an innovative teacher preparation program.

Purpose and Research Questions

Given the need to incorporate opportunities for engaging prospective teachers in reflection and making their personal theorizing explicit and the potential of hypermedia authoring to support this kind of reflection and make thinking visible, this study aimed to answer the question: What are the prospective elementary teachers' views of teaching and learning science as they became transparent through their web-based philosophies. Specifically, the questions that guided this research are:

1. What is the nature of prospective elementary teachers' philosophies about science teaching and learning?
2. In what ways does the web-based portfolio task support thoughtful reflection associated with learning to teach science?
3. In what ways does the technology contribute to the portfolio task?

Research Methods

Design

This study manifests the characteristics of a multi-participant case study (Merriam, 1998). For the purpose of this study, two individuals were investigated within the larger case of prospective elementary teachers' understanding of teaching science with the support of web-based portfolios. These two individuals were chosen because it was believed by the researcher that their representativeness would lead to main assertions about prospective teachers' understandings of teaching science. Both of the participants were traditional prospective elementary teachers (i.e., 22 years old, females with no science-specific background). In order to maintain the confidentiality of the participants, the pseudonyms Sarah and Jane were used in all aspects of this study.

Context

As described by the instructor of the course (Zembal-Saul, 2001) the participants in this study were members of a cohort of prospective elementary teachers engaged in a year-long internship program. The prospective teachers spent the entire year in one of four professional development schools (PDSs) that developed through an ongoing local school-university partnership. The web-based philosophy project was structured as an evidence-based argument about teaching and learning science that is developed over time. Prospective teachers generate a series of assertions or claims, support those claims with multiple pieces of evidence/artifacts (e.g., course projects, classroom observations), and justify evidence in light of the claims they make. Over the course of the semester, claims could be added, modified, or rejected on the basis of new evidence (Zembal-Saul, 2001). An example of the main page of the web-based portfolio is presented in Figure 1.

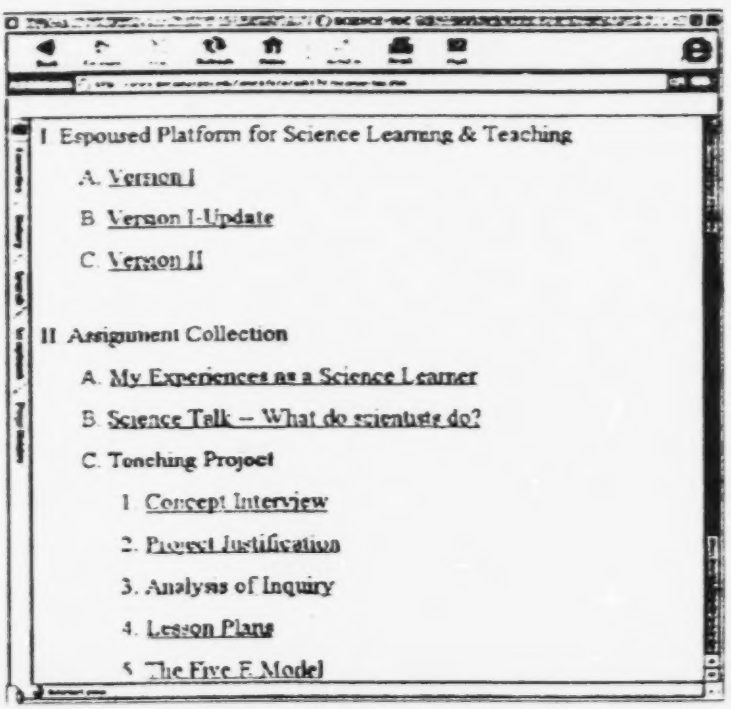
I Espoused Platform for Science Learning & Teaching
A. Version I
B. Version I-Update
C. Version II
II Assignment Collection
A. My Experiences as a Science Learner
B. Science Talk – What do scientists do?
C. Teaching Project
1. Concept Interview
2. Project Justification
3. Analysis of Inquiry
4. Lesson Plans
5. The Five E Model

Figure 1. Sample of the main page of a web-based portfolio.

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Data Sources

Multiple sources of data were used in this study. The main source of data were the web-based portfolios that the participants developed during the Fall 2000 semester. More specifically, this study investigated three versions of the web-based science teaching philosophies that each of the participants developed as part of their web-based portfolios. Another source of data were the reflection statements developed by each of the participants. In their reflection statements, prospective teachers were asked to discuss what changes were made in the different versions of their philosophies and explain why. Specifically, participants were asked to reflect on how they saw their science teaching philosophies changing over time and to comment on the revisions they were making in each iteration (Zembal-Saul, 2001).

Data Analysis

Three analytic techniques were used to analyze the data: pattern-matching, explanation-building, and time-series analysis (Yin, 1984). A combination of these techniques was used in order to examine the progress of the two participants' understandings about learning to teach science, as it became evident from the nature of the three versions of their science teaching philosophies. Furthermore, a content analysis of the participants' reflective statements was done in order to illuminate their understandings of how their views of teaching and learning were changing over time.

In order to investigate how technology contributed to the task, the way participants made use of the multimedia possibilities of the web-based forum and the way they used hyperlinking were investigated. Specifically, the kinds of artifacts the participants used as evidence in the three versions of their philosophies and how they

chose to link further information and artifacts within the text were examined. After the within-participant analysis was done, a cross-participant analysis followed in order to identify similarities and differences across the two participants.

Findings and Interpretations

Data from the three versions of the participants' science teaching philosophies and from their two reflection papers were analyzed in order to explore the nature of their philosophies, the ways that the web-based portfolio task supports thoughtful reflection and the ways technology contributes to this task. The findings are described based on the assertions that were made around three core areas: a) Insights into participants' thinking; b) Insights into context; and c) Insights into the task and particularly the role of technology.

Insights into participants' thinking

Overall, the claims that both of the participants developed, transformed from being generic in initial versions of their philosophies to being precise and science specific in the final versions. The claims that Sarah and Jane developed throughout the three versions of their philosophies are presented in Table 1. and Table 2. Both of the participants became more sensitive to children's thinking and learning and emphasized a student-centered approach, which became evident in their science teaching philosophies. Specifically, they seemed to be sensitive to the needs of children and to consider their preconceptions about science. As teachers, they recognized the need to design lessons based on their students' needs and interests and encourage them to express their ideas. This finding is significant because it stands in contrast to the literature that suggests that prospective teachers view themselves as the transmitters of knowledge to the children

(e.g., Aguirre & Haggerty, 1995; Aguirre, Haggerty & Linder, 1990; Cohen, as cited in Prawat, 1992).

The nature of the claims that the participants developed in the initial versions of their philosophies supports the findings of previous studies that report beginning teachers tend to emphasize the physical engagement of children in activities. Particularly, both of the participants emphasized the fact that children learn through hands-on activities. According to Prawat (1992), this is firmed with a set of beliefs about teaching and learning, termed 'naïve constructivism'. As Prawat (1992) stated, beginning teachers have the notion that student interest and involvement (i.e., in 'hands-on activities') constitutes both a necessary and sufficient condition for worthwhile learning. However, this is just as problematic from a constructivist perspective: the tendency to equate activity with learning (Prawat, 1992). However, in the second and third versions of their philosophies, the participants of this study made the connection of physical engagement with more conceptual aspects of learning. Not only did the participants refer to 'minds-on' activities, but they also justified this statement. They explicitly stated that it is not enough to engage children in hands-on activities in order to support their learning. Recall that in the third version of her philosophy Maria stated:

> Hands-on/minds-on activities go a step beyond traditional hands-on activities, asking children to think about and explain science concepts. The focus is on what children are going to learn rather than what children are going to do. The activity moves beyond the realm of hands-on and requires students to apply their minds to the activity. (Maria, 3rd version)

In a similar way, Janice explained: "Students need to experience science concepts by using their senses to see first hand how science works. However, just the experiences aren't enough. Students also need to be able to think about the hows and whys of the science".

Table 1
Jane's claims across the three versions of her philosophy

Versions	Claims
V1	Children learn science by asking questions. Children learn science by relating it to the world outside through hands-on activities. Children learn science by being challenged to reflect deeply on science observations.
V2	Children learn science by asking questions. Children learn science by experiencing it through hands-on and minds-on activities. Children learn science by being able to reflect deeply on science observations. Teachers support science learning best when they ask questions to probe students' thinking as opposed to asking questions to elicit a certain answer.
V3	Same as Version 2.

Table 2
Sarah's claims across the three versions of her philosophy

Versions	Claims
V1	Children learn science through hands-on activities.
	Children learn science through inquiry-based investigations.
	Children learn science through activities that engage and challenge all learners.
	Teachers can support children's learning by modeling joy in science.
	Teachers can support children's learning by creating a safe and collaborative learning environment.
V2	Children learn science through hands-on and minds-on activities.
	Children learn science through inquiry-based investigations.
	Children learn through talking about science.
	Teachers can support children's learning by mediating their science experiences.
V3	Children learn science through hands-on and minds-on activities.
	Children learn science through inquiry-based investigations.
	Children learn best through talking about science.
	Children learn science through collaboration.
	Teachers can support children's learning by mediating their science experiences.

A pattern that was observed throughout the participants' web-based portfolios and particularly within their justification statements, was that they became more focused on the essential features of inquiry (National Research Council, 1996). The emphasis on teaching science as inquiry was evident in justification statements that emphasized question-driven investigations, the use of observational data, making connections between evidence and explanations and communicating these explanations to others. Inquiry into authentic questions generated from students' experiences is the central strategy for teaching science (National Research Council, 1996, p. 31). According to the *National Science Education Standards*, in inquiry, the focus is on children cooperatively investigating and developing an understanding of their world, and at the same time, learning about science as inquiry – procedures, scientific habits of mind, and significant

knowledge of science content (National Research Council, 1996, p. 133). This finding is important because it reveals that the participants considered inquiry-based teaching, which reveals that their views were consisted with contemporary reform efforts in science education.

Insights into context

In addition to insights into prospective teachers' views, the web-based portfolios revealed the significance of the Professional Development Schools (PDSs) context and its impact on the participants' learning. Web-based portfolio served as a bridge between the university coursework and field experiences. It provided the vehicle for prospective elementary teachers to make connections between what they were learning in their science methods course and what they were applying in their practices.

As it became apparent through the participants' web-based philosophies, the greatest influence on their learning were the model lessons they experienced in the science methods course. In addition, moving from the first to the third versions of their philosophies, participants incorporated more evidence drawn out of their teaching experiences while they continued using evidence drawn from their science methods experiences. This suggests that the participants were making connections between university coursework and field experiences; that is, making connections between their experiences outside the classroom and their experiences in the classroom. This finding is significant, because as Putnam and Borko (2000) pointed out, "Teachers, both experienced and novice, often complain that learning experiences outside the classroom are too removed from the day-to-day work of teaching to have a meaningful impact" (p. 6). Thus, in the case of prospective teachers, it is important to combine their experiences

in their methods courses with their field experiences. Such an approach can be enhanced through the Professional Development Schools (PDSs). Recently, PDSs have been recognized for their potential to provide unique opportunities to integrate university coursework and field experiences (Darling-Hammond, 1994, Levine & Trachtman, 1997, as cited in Zembal-Saul, 2001), bridging the theory - practice divide.

The role of the task and the technology

In this study, web-based portfolios provided a place where prospective teachers articulated their science teaching philosophies and presented them in a hypermedia format. In particular, web-based portfolios made participants' thinking visible and documented their growth. As Loughran and Corrigan (1995) noted, "A major focus of the process of developing a portfolio and the product is to help prospective teachers begin to articulate their understanding of what they think it means to be a teacher" (p. 17).

The findings of this study also are congruent with the literature that suggests that portfolio development may support reflection. The justification statements appeared to be a powerful technique for engaging prospective teachers in meaningful reflection since they required explicit and justified connections between the claims and evidence used to support them. According to Nettles and Petrick (1995), writing a rationale allows prospective teachers to reflect on their work, both in deciding for which outcome the artifact provides evidence and in realizing their proficiency in that particular teaching strategy or skill. In this study, web-based portfolios served as a vehicle for prospective teachers to reconsider and reevaluate their views of teaching and learning science in light of new learning experiences.

In addition, prospective teachers engaged in metacognitive activities while developing their philosophies. The development of a personal science teaching philosophy required them to think about their knowledge, understandings, ideas and beliefs about learning and teaching. Web-based portfolios provided the vehicle through which prospective teachers explored their understandings of learning to teach, through the development of different versions of their science teaching philosophies. According to Hoban (1997), prospective teachers should be encouraged to be metacognitive and become more aware of how they learn in teacher education courses with the intention of informing their decision-making as they construct their personal pedagogies.

Another important element of the task was the development of evidence-based claims by the prospective elementary teachers. Explanations and evidence are essential to our understanding and evaluation of claims (Brem & Ribs, 2000). However, several lines of research (e.g., Kuhn, 1991) have found that people have difficulties in making distinctions between and the respective roles of explanation and evidence in an argument. In this study, the web-based portfolio development engaged prospective elementary teachers in evidence-based claims construction, which proved to be to be a good strategy for supporting their ability to distinguish evidence and explanation. Having to craft justification statements, prospective elementary teachers had to explicitly distinguish between the claims they made, the evidence they used to support their claims and the explanation used to back up their evidence.

The web-based forum supported the engagement of prospective teachers in meaningful reflection since it allowed them to keep multiple versions of their philosophies. Thus, prospective teachers could look back to prior versions of their

philosophies, build on their initial ideas, revise their views about teaching and learning science and easily reorganize their philosophies. Prospective teachers were able to view how their philosophies were changing over time, which supported a continuous engagement in metacognition, self-evaluation and self-reflection.

According to Morris and Buckland (2000), by compiling the portfolios in a web-based environment, prospective teachers are able to use the hyperlinking capabilities to organize the presentation in such a way that demonstrates their unique understanding of their own learning. Additionally, with the use of hyperlinking prospective teachers are able to reorganize their philosophies only by modifying some links.

The hypermedia component fosters connections between coursework, concepts, and applications because it allows the individual to designate links between ideas and themes (Morris & Buckland, 2000). The multimedia possibilities of the web-based portfolios allowed prospective elementary teachers to make nonlinear, dynamic representations of their science teaching philosophies. Through the hyperlinking process, prospective teachers made connections between their coursework and field experiences, between their claims, evidence and justification statements which resulted in an interconnected presentation of their learning experiences.

Another aspect of the web-based forum is its public nature since it makes the portfolio available to a variety of audiences. The web-based portfolio has the potential of being viewed by a greater number of people. Thus, greater effort and pride is taken to create a public document (Aschermann, 1999, p. 3). Moreover, the public nature of the web-based portfolios provides the opportunity for prospective teachers to give and receive feedback from peers or professors instantly. They are easier to share, making it

possible for prospective teachers to see a variety of exemplars, view other perspectives of teaching and learning and challenge their own practices and beliefs (Morris & Buckland, 2000).

Conclusions

Given the findings of this study, it appears that the web-based philosophy task was conductive to making prospective elementary teachers' implicitly held personal pedagogical theories explicit and promoting their revision in light of new experiences and learning. In addition, the context appears to have supported the development of reform-oriented claims that emphasized children's thinking. Moreover, prospective teachers were able to conceptualize connections among what they were learning in class and what they were experiencing in schools. This type of integration has the potential to play a powerful role in increasing the robustness of emergent reform-oriented pedagogical theories and their influence on instruction. The next phase of our research will explore this potential.

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